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Environmental Restoration Project  
Standard Operating Procedure

for:

# Pumping Tests

**Los Alamos**  
NATIONAL LABORATORY

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Los Alamos, New Mexico 87545

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## Revision Log

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# Pumping Tests

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# Pumping Tests

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process for performing pumping tests to determine the hydraulic properties of water-bearing geologic materials at the Los Alamos National Laboratory (Laboratory) ER Project.

## 2.0 SCOPE

This SOP is a mandatory document and shall be implemented by all ER Project participants when performing pumping tests for the ER Project.

## 3.0 TRAINING

- 3.1 All users of this SOP are trained by reading the procedure, and the training is documented in accordance with QP-2.2.
- 3.2 The FTL shall monitor the proper implementation of this procedure and ensures that relevant team members have completed all applicable training assignments in accordance with QP-2.2.

## 4.0 DEFINITIONS

**Note:** A glossary of definitions can be located on the ER Project internal homepage <http://erinternal.lanl.gov>.

- 4.1 Aquifer — A geologic material that stores and transmits water at sufficient rates to supply a well; confined — when not open to the atmosphere due to the presence of an impermeable or confining layer; unconfined — when open to the atmosphere through openings in the overlying geologic units. As used below includes saturated zones of any productivity.
- 4.2 Pumping Test — A test made by pumping a well for a period of time and observing the change in hydraulic head in the aquifer. Data collected are used to determine the capacity of the well and hydraulic characteristics of the aquifer.
- 4.3 Drawdown — The lowering of the water table in an unconfined aquifer, or potentiometric surface for a confined aquifer, resulting from pumping of wells. Also, the decrease in water level in a well that is being pumped or is in proximity to a pumping well.
- 4.4 Hydraulic conductivity — The rate of fluid flow in gallons per day through a cross section of one square foot (gpd/ft<sup>2</sup>) of a permeable medium under a unit hydraulic gradient at the prevailing temperature or at 16°C. It is a

function of both the medium and of the fluid flowing through it. Also known as the coefficient of permeability or Meinzer unit.

- 4.5 Potentiometric Surface — For a confined aquifer, an imaginary surface that represents the height to which water will rise in a well or series of wells. For an unconfined aquifer, the potentiometric surface is called the water table.
- 4.6 Recovery — The water-level rise in a well after the pump has been shut off.
- 4.7 Site-Specific Health and Safety Plan (SSHASP) — A health and safety plan that is specific to a site or ER-related field activity that has been approved by an ER health and safety representative. This document contains information specific to the project including scope of work, relevant history, descriptions of hazards by activity associated with the project site(s), and techniques for exposure mitigation (e.g., personal protective equipment [PPE]) and hazard mitigation.
- 4.8 Specific yield — The ratio of the volume of water that a given mass of saturated rock or soil will yield by gravity to the volume of the mass expressed as a percentage (dimensionless). It is sometimes referred to as the unconfined storativity.
- 4.9 Storage coefficient — The volume of water that a confined aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (dimensionless).
- 4.10 Transmissivity — The rate at which water is transmitted through a unit width of the full saturated thickness of an aquifer under a unit hydraulic gradient expressed in gallons per day per foot (gpd/ft). Transmissivity is numerically equal to the product of hydraulic conductivity and saturated thickness of the aquifer.

## **5.0 BACKGROUND AND PRECAUTIONS**

- 5.1 This SOP shall be used in conjunction with an approved SSHASP. Also, consult the SSHASP for information on and use of all PPE.
- 5.2 A pumping test is a controlled field procedure to determine the hydraulic properties of water-bearing geologic units. Aquifer characteristics that may be obtained from pumping tests include hydraulic conductivity (K), transmissivity (T), specific yield (Sy) for unconfined aquifers, the storage coefficient (S) for confined aquifers, and the vertical hydraulic conductivity of confining layers. Also, the occurrence and position of recharge or impermeable boundaries can be identified. These parameters can be determined by graphical solutions and computerized programs.
- 5.3 Pumping tests are generally carried out by monitoring the water level over time in the pumping well and in each observation well (if available) while the

pumping well is being discharged at a constant rate. Such tests provide results that are more representative of aquifer characteristics than those obtained by other methods. They can also be used to determine the hydraulics of secondary aquifer flow. However, pumping tests require a greater degree of labor activity and expense than other methods and therefore may not always be justified for all levels of investigation.

- 5.4 Refer to the site-specific work plan for the duration of the pumping test, the location of the observation well, and the data to be collected. Collection of measurements and documentation of data will be performed as described in Section 8.2.

## **6.0 RESPONSIBLE PERSONNEL**

The following personnel are responsible for activities listed in this SOP:

- 6.1 Focus Area Leader
- 6.2 Team Leader
- 6.3 Quality Program Project Leader
- 6.4 Author
- 6.5 ER Project personnel

## **7.0 EQUIPMENT**

A checklist of suggested equipment and supplies needed to implement this procedure is provided in Attachment A. Descriptions of commonly used equipment items and their capabilities are listed below.

- 7.1 *Electric Water-level Meter* — A spool-mounted, flat graduated tape attached to a stainless-steel electrode that emits an audible and visual signal when contact with water is made.
- 7.2 *Electronic Data Logger* — An electronic device that can be programmed to receive electric impulses, that are stored as data. Pressure transducers are designed to be used with automatic data-logging instruments and send a current to the data logger. The current is proportional to the pressure and can be converted to meaningful units by the data logger.
- 7.3 *Pressure Transducer* — An electronic probe connected to a wire cable that is lowered into the water column of a well to measure pressure, or *head*. The pressure measured is the total pressure which includes both the hydrostatic pressure of the water column above the transducer and the atmospheric pressure at the water surface. Changes in pressure are proportional to changes in the water-level.

## 8.0 PROCEDURE

**Note:** Subcontractors performing work under the ER Project's quality program may follow this (SOP) for performing aquifer pumping tests. Subcontractors may use their own procedure(s) provided the substitute meets the requirements prescribed by the ER Project Quality Management Plan, and have been approved by the ER Project's Quality Program Project Leader (QPPL) before starting the activity(s).

**Note:** ER Project personnel may produce paper copies of this SOP printed from the controlled-document electronic file located at website [http://erinternal.lanl.gov/home\\_links/Library\\_proc.htm](http://erinternal.lanl.gov/home_links/Library_proc.htm). However, it is their responsibility to ensure that they are properly trained and are utilizing the current version of this procedure. The author may be contacted if text is unclear.

**Note:** Deviations from SOPs are made in accordance with QP-4.2, Standard Operating Procedure Development. Procedure deviations are documented in accordance with QP-5.7, Notebook Documentation for Environmental Restoration Technical Activities.

### 8.1 Preoperation Activities

8.1.1 Ensure that permission to discharge is obtained (an NPDES Permit may be required) or that a containment system is available for collecting the water that will be pumped during the test. This is especially important for wells that may produce contaminated water. Consult SOP-01.06, Management of Environmental Restoration Project Wastes, in the event that the site-specific work plan requires containerization of pumped water as waste.

8.1.2 Confirm from the site drilling crew that well installation is complete and that the equipment necessary to conduct the pumping test is deployed. All wells should be properly developed before testing.

8.1.3 Obtain the pumping test equipment, appropriate operating manuals, and information on equipment modifications necessary to conduct a pumping test. Check the equipment for proper functioning. The drilling crew is responsible for supplying equipment and completing the following tasks:

8.1.3.1 Installing a submersible or turbine pump.

8.1.3.2 Installing a flow meter in the discharge line of the pumping well to accurately measure and monitor the volume of discharge.

- 8.1.3.3 Installing sufficient pipe to transport the discharge from the pumping well away from the area to prevent infiltration of extracted water into the pumped zone.
- 8.1.3.4 Installing a gate valve along with a pressure regulator on the discharge pipe to control the pumping rate.
- 8.1.3.5 Placing an outlet near the well head, but past the totalizer and flow meters, for water-quality monitoring and sampling.
- 8.1.4 Ensure that all gauges, transducers, flow meters, and other equipment used in conducting pumping tests are properly calibrated before use in accordance with QP-5.2. If necessary, perform any on-site zero adjustment or calibration and document those procedures.
- 8.1.5 It is advisable to monitor and record water levels at the test site for about one week before performing the test using a continuous recording device. These records establish the barometric efficiency of the aquifer. The records also help determine if the aquifer is experiencing an increase or decrease in head over time that may be caused by recharge or pumping in the nearby area or by diurnal variations.

## 8.2 Pumping and Recovery Test Operations

Pumping tests consist of two phases: (1) an initial pumping phase resulting in water-level drawdown, and (2) a recovery phase after the pump has been turned off. Water-level monitoring is conducted throughout both of these phases.

- 8.2.1 When all equipment has been deployed, manually measure static water levels in the test well and any observation well(s) using a water-level meter. Read and record the totalizer value from the in-line flow meter prior to turning on the pump. At a predetermined time zero, initiate pumping at a specified discharge rate and immediately begin time-series water-level measurements in the test and observation wells. Measure all depths to water from a designated reference marker point (measuring point) as prescribed in SOP-07.02.
- 8.2.2 If measuring water level manually, the frequency of readings will vary with time of pumping. Rapid drawdown in the test well is likely to occur during the first several minutes after the pump has been turned on. This is because the first water to be produced is extracted, not from the formation, but from the well casing and the highly permeable filter-pack around the well screen. Therefore, early measurements are taken frequently while those later in the test are taken less frequently. For example, water-level measurements in the test well



may be taken at 15-second intervals for the first 15 minutes after time zero, every 30 seconds for the next half hour, every 1 minute for the next two hours, and so on with decreasing frequency over time until pumping stops. Continue to monitor water levels during the recovery phase of the test. Recommended standard references for guidance on measurement frequency include Kruseman and DeRidder (1970), Saunders (1998), and Walton (1987).

- 8.2.3 Water-level changes in observation wells will occur after a delayed period of time. Changes will be observed when the effects of drawdown surrounding the pumping well (i.e., the cone of depression) have expanded a sufficient distance to reach the observation well. Depending on the radial distance from the pumping well, water-level measurements in observation wells may be taken every 15 minutes initially, every 30 minutes for several hours, and once each hour thereafter until pumping stops. Continue to monitor water levels during the recovery phase of the test.
- 8.2.4 To reduce field personnel time during the pumping test, continuous recording of water-level changes in the test and observation wells can be accomplished using electronic pressure transducers and data loggers. If using an electronic pressure transducer and data logger, follow operating instructions prescribed in SOP-07.01. Drawdown and recovery changes may be monitored in real time by connecting the pressure transducer to a lap-top computer.
- 8.2.5 Barometric pressure should be recorded during the test. The barometric data, as well as projected pre-test water-level trends, may be applied as corrections to water-level readings so that the reduced data are representative of the hydraulic response in the aquifer to pumping from the test well.
- 8.2.6 The duration of the test is determined by the needs of the project and the aquifer properties. In general, longer tests produce more definitive results. A duration of one to several days, followed by a similar period of monitoring the recovery of the water level, is desirable.
  - 8.2.6.1 The pumping test may be discontinued if the water level becomes constant with time. This normally indicates that a hydrogeologic source or leaky aquifer condition has been intercepted and that additional useful information will not be collected by continued pumping.

8.2.6.2 A simple procedure for determining the adequacy of data is to plot the log of time versus drawdown for the most distant observation well. When the plot becomes a straight line on the semilog graph paper, enough data has been collected. Ideally, the straight line should continue over at least one log cycle.

8.2.7 The time when the pump is shut off marks the beginning of the recovery phase of the test. Perform the following to complete the test:

8.7.1 After the pump has been shut off, water-level monitoring is maintained while water recovers in the test and observation well(s). Continue monitoring for a period of time equal to one-half that of the pumping portion of the test or until the water in these wells has stabilized at levels that approach their pre-test static values.

8.7.2 Read and record the totalizer value from the in-line flow meter after the pump is turned off.

8.7.3 When full recovery has been reached, or nearly so, in the test and observation well(s), monitoring is ceased and the pumping test is complete. Begin postoperation procedures.

### 8.3 Documentation

8.3.1 When electronic pressure transducers and data loggers are used to monitor the pumping test, store all data internally or on computer diskettes or tape. A laptop computer should be used in the field to view data and assure the equipment is working properly. Transfer the information directly to the main computer to analyze it. Periodically take measurements manually and record in a field notebook to verify the data recorded by the data logger.

8.3.2 All manually collected data should be recorded in a field notebook. Transfer appropriate data onto the Pumping/Recovery Test Data form (Attachment B). Fill out the form as described in the completion instructions that follow Attachment B.

### 8.4 Postoperation Activities

8.4.1 If using an electronic data logger, follow the steps in the data logger software to end the test. These steps include:

- Stop the logging sequence
- Save memory and disconnect battery at the end of the day's activities.

8.4.2 Decontaminate the water-level device, transducer(s) and cable(s) as specified in SOP-01.08.

#### 8.5 Lessons Learned

During the performance of work, ER Project personnel shall identify, document and submit lessons learned in accordance with QP-3.2, Lessons Learned. This QP can be located at website:

[http://erinternal.lanl.gov/home\\_links/Library\\_proc.htm](http://erinternal.lanl.gov/home_links/Library_proc.htm).

## 9.0 REFERENCES

The following documents have been cited within this procedure.

QP-2.2, Personnel Orientation and Training

QP-3.2, Lessons Learned

QP-4.2, Standard Operating Procedure Development

QP-4.3, Records Management

QP-5.2, Control of Measuring and Test Equipment

SOP-01.04, Sample Control and Field Documentation

SOP-01.06, Management Environmental Restoration Project Wastes

SOP-01.08, Field Decontamination of Drilling and Sampling Equipment

SOP-07.01, Pressure Transducers

SOP-07.02, Fluid Level Measurements

Kruseman, G. P., and DeRidder, N. A., 1970, Analysis and evaluation of pumping data: International Institute for Land reclamation and Improvement, Bull. 11, Wageningen, The Netherlands.

Sanders, L. L., 1998, A manual of field hydrogeology: Prentice Hall, Upper Saddle River, New Jersey.

Walton, W. C., 1987, Groundwater pumping tests — design and analysis: Lewis Publishers, Chelsea, Michigan.

## 10.0 RECORDS

The FTL is responsible for submitting the following records (processed in accordance with QP-4.4, Record Transmittal to the Records Processing Facility) to the Records Processing Facility:

10.1 A completed Pumping/Recovery Test Data form (Attachment B).

10.2 A completed Water-Level Elevation Data Sheet (Attachment B in SOP-07.02).

10.3 Completed Daily Activity Log form (Attachment E in SOP-01.04) or field notebook containing deviations, calibration data, and all other pertinent information.

## 11.0 ATTACHMENTS

The document user may employ documentation formats different from those attached to/named in this procedure—as long as the substituted formats in use provide, as a minimum, the information required in the official forms developed by the procedure.

Attachment A: Equipment and Supplies Checklist for Aquifer Pumping Tests (1 page) located at <http://erinternal.lanl.gov/Quality/forms.htm>.

Attachment B: Pumping/Recovery Test Data (form and completion instructions) (3 pages) located at <http://erinternal.lanl.gov/Quality/forms.htm>.

[Using a token card, click here to record "self-study" training to this procedure.](#)

If you do not possess a token card or encounter problems, contact the RRES-ECR training specialist.

## Equipment and Supplies Checklist for Aquifer Pumping Tests

- \_\_\_\_\_ Pressure transducer
- \_\_\_\_\_ Electric water-level indicator
- \_\_\_\_\_ Weighted tapes with plover
- \_\_\_\_\_ Steel tape (subdivided into tenths of feet)
- \_\_\_\_\_ Electronic data logger (if transducer method is used)
- \_\_\_\_\_ Laptop computer
- \_\_\_\_\_ Tape measure (subdivided into hundredths of feet)
- \_\_\_\_\_ Watch or stopwatch with second hand
- \_\_\_\_\_ Semilog graph paper (if required)
- \_\_\_\_\_ Waterproof-ink pen
- \_\_\_\_\_ Thermometer
- \_\_\_\_\_ Appropriate references and calculator
- \_\_\_\_\_ Barometer or recording barograph (for tests conducted in confined aquifers)
- \_\_\_\_\_ Daily Activity Log forms
- \_\_\_\_\_ Pumping/Recovery Test Data forms
- \_\_\_\_\_ Groundwater Elevation forms
- \_\_\_\_\_ Any PPE listed or required in the SSHASP
- \_\_\_\_\_ Any additional supplies listed in associated procedures, as needed
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
- \_\_\_\_\_
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SOP-07.04

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Test Location \_\_\_\_\_ Pumped Well \_\_\_\_\_ Observation Wells \_\_\_\_\_ Sheet \_\_\_\_\_ of \_\_\_\_\_

Source of Data Below \_\_\_\_\_ Distance from Pumped Well (ft) \_\_\_\_\_ Measuring Point \_\_\_\_\_

Test Started: Date \_\_\_\_\_ Time \_\_\_\_\_ Pre-test Static Water Level (ft) \_\_\_\_\_

Test Ended: Date \_\_\_\_\_ Time \_\_\_\_\_ Final Water Level (ft) \_\_\_\_\_

Initial Flow Meter Reading (gal) \_\_\_\_\_ Final Flow Meter Reading (gal) \_\_\_\_\_

Pump Capacity (type/hp) \_\_\_\_\_ Range of Pumping Rates (gpm) \_\_\_\_\_

Average Pumping Rate (gpm) \_\_\_\_\_

Test Conducted by \_\_\_\_\_

(Print name and title, then sign)

(Print name and title, then sign)

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(ER2001-0366)

## **Completion Instructions for the Pumping/Recovery Test Data Form**

Use an indelible dark-ink pen. Use one form, or series of forms, for each well in which measurements are made. To change an entry, draw a single line through it and amend the entry with the correct information. Date and initial the change. Complete the following information:

### **Header Information:**

1. Test Location – Technical Area, Canyon, well field etc. where the activity is being performed.
2. Pumped Well — Well in which stress is induced. Also test well.
3. Observation Well(s) — Well(s) located at some distance for the test well to be monitored. One or more observation wells may be monitored.
4. Sheet Number—Number all the sheets that are used for this activity.
5. Source of Data Below – specify the well from which the data recorded on the form came (pumped well, observation well 1, 2, etc.).
6. Measured Distance from Test Well to Observation Well (ft)— measure and record this distance to the nearest tenth of a foot.
7. Measuring Point — describe the physical reference mark from which all manual water-level measurements are made (e.g., TOC, top of casing). Also give the distance above ground surface of measuring point (ft).
8. Test Started — Record date, time when pumping began (i.e., time zero), and pre-test static depth to water (DTW) to the nearest hundredth of a foot.
9. Test Ended — Record date, time, and final DTW measurement at the end of the pumping portion of the test (i.e., when the pump was turned off and when the recovery portion of the test begins).
10. Initial and Final Flow Meter Readings (gal) — Record readings in gallons made from the in-line flow meter immediately prior to the time the pump is turned on and after the pump has been turned off.
11. Pump Capacity — Record pump type, model, and capacity in horsepower.
12. Range of Pumping Rates (gpm) --- Low and high discharge rates over course of test. Check frequently.
13. Average Pumping Rate (gpm) — Record the average flow rate in gallons per minute over the course of the pumping period. Divide the total gallons pumped by the total elapsed time of pumping.

14. Test Conducted by — Print name and position title, then sign.

Weather and Other Comments. Record all other conditions pertinent to the sample collection in this section on the Daily Activity Log form in ER-SOP-1.04.

Pumping Test

1. Date and Time (date:hour:minutes) — Day and time of water-level measurement during the pumping portion of the test using the suggested format: DD-MMM-YY (e.g., 01-JAN-91) and the 24-hr clock time (0837 for 8:37 a.m. and 1912 for 7:12 p.m.).
2. Elapsed Time (min) — Cumulative time of measurement, to the nearest minute, since time zero (i.e., when the pump was turned on).
3. Depth to Water (ft) — DTW to the nearest hundredth of a foot in the well monitored.
4. Pumping Rate (gpm) — Flow rate in gallons per minute measured from the in-line flow meter. *This column is applicable only for the form used to record test well data.*

Recovery Test

1. Date and Time (date:hour:minutes) — Day and time of water-level measurement during the recovery portion of the test. Suggested format as above.
2. Elapsed Time (min) — Time of measurement, to the closest minute, since time zero (i.e., when the pump was turned on).
3. Depth to Water (ft) — DTW to the nearest hundredth of a foot corresponding to the water-level measurement in the test or observation well.